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2. Patent application number *(The Patent Office will fill in this part)*	19 MAR 1999 **9906451.1**
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Madge Networks Limited 100 Lodge Lane Chalfont St. Giles Bucks HP8 4AH
Patents ADP number *(if you know it)*	4410866001
If the applicant is a corporate body, give the country/state of its incorporation	Great Britain
4. Title of the invention	COMMUNICATIONS NETWORK BRIDGE
5. Name of your agent *(if you have one)*	GILL JENNINGS & EVERY
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Broadgate House 7 Eldon Street London EC2M 7LH
Patents ADP number *(if you know it)*	745002

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Claim*(s)*	3
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Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

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COMMUNICATIONS NETWORK BRIDGE

The present invention relates to a bridge for use in a group of bridges in a communications network which operates in accordance with a Spanning Tree Protocol (STP) and to a method of implementing the STP on a network having a group of bridges.

The STP is a method described in the IEEE 802.1D standard for controlling bridging paths through a network. To avoid problems caused by bridging loops in the network, this protocol temporarily eliminates loops by disabling ports so that there is only one possible path for the transmission of data packets across the network. In general, this protocol also aims to create a path that is more efficient and typically has a higher bandwidth than alternative paths.

Operation of the STP will now be described with reference to the network system shown in Figure 1. The example network system comprises a number of local area networks (LANs) 10,11,12,13,14,15 which are interconnected via a number of bridges 1,2,3,4,5,6. The bridges, which are provided to transfer data between the different LANs, are physically coupled to the LANs via ports 7,8,9.

Each bridge 1,2,3,4,5,6 is assigned a unique bridge identifier B1,B2,B3,B4,B5,B6 which is based on the MAC address of the respective bridge, the bridge identifier incorporating an associated priority indicated by a priority number. The bridge having the highest priority, which is indicated by the lowest priority number, is designated as the root bridge, which in the present example is the bridge 1.

Each port 7,8,9 of each bridge 1,2,3,4,5,6 is assigned a unique port identifier, which incorporates a respective port priority. Each port also has an associated path cost component. The path cost components are representative of the port's ability to transfer data. Typically the path cost value is set by default to a pre-set value, but can be re-set by a user to a lower value so as to focus traffic on

that particular port (or to a higher value to divert traffic away). Thus a port having a higher bandwidth is assigned a lower cost indicating an easier transfer whereas a lower bandwidth port is assigned a higher path cost component. The path cost components are used to calculate an overall path cost indicting the total cost of transferring data to the root bridge 1.

For each bridge, the ports 8 which are closest to the root bridge B1 are used to forward data to the root bridge and these are therefore known as root ports 8.

The details of each bridge including bridge and port identifiers, bridge and port priorities and the like are stored in an internal memory of the respective bridge.

The path costs are used by the bridges 1,2,3,4,5,6 to determine a designated bridge for each LAN. The designated bridge is the bridge 1,2,3,4,5,6 having the lowest path cost for transferring data from the respective LAN to the root bridge 1. In the present example, the designated bridges are the bridges 2,3,4,5 for the LANs 12,13,14,15 respectively. The ports 7 which couple a designated bridge to the respective LAN are known as designated ports 7.

Any port 9 which is not a root port 8 or a designated port 7 is placed in a blocking mode. This prevents data being transferred via this port 9 thereby removing any loops from the network topology. If identical path costs are determined from a LAN to the root bridge 1, via two different bridges, then the bridge having the highest priority is the designated bridge. If the bridges have the same priority, then the priority of the respective ports is used to determine the designated bridge and the designated port.

The root bridge 1 and designated bridges 2,3,4,5 are determined by having all the bridges 1,2,3,4,5,6 communicate with each other to determine details of respective path costs and priority information. This is achieved by transmitting configuration Bridge Protocol Data Units (hereinafter referred to as BPDUs) between the

bridges, and having each bridge maintain a record of the information contained therein. This is stored in the memory in the form of topology data which indicates the status of each port of the respective bridge along with an indication of the root bridge.

An example of such a BPDU data packet is shown in Figure 2. This includes a bridge field 20, which indicates the bridge identifier B1,B2,B3,B4,B5,B6 of the bridge sending the BPDU, a root field 21 which indicates the bridge identifier B1 of the root bridge 1, a port field 22, which indicates the port identifier of the port 7,8,9 with which the BPDU is associated and a root path cost field 23 which indicates the path cost back to the root bridge 1 from the respective port 7,8,9. There are also additional fields indicated generally at 24, although these are not relevant for the purposes of the present description.

Initially, each bridge 1,2,3,4,5,6 assumes it is the root bridge, and accordingly, it generates a BPDU inserting its own bridge identifier B1,B2,B3,B4,B5,B6 in the root field 21. Similarly a respective port 7,8,9 is identified in the port field 22, and a value of zero is inserted in the root path cost field 23, as the cost of transferring data from the bridge to itself is zero. The generated BPDU is then transmitted to all the other bridges via the LANS 10,11,12,13,14.

Upon receipt of a BPDU, each bridge will compare the priority of the bridge identifier B1,B2,B3,B4,B5,B6 indicated in the root field to the priority of the bridge identifier B1,B2,B3,B4,B5,B6 of the root bridge indicated in the topology data. If the indicated root bridge has a higher priority than the bridge identified in the BPDU, the bridge will discard the BPDU. If no root bridge is indicated in the topology data, the bridge will compare the root bridge identifier indicated in the BPDU with its own identifier and if its own identifier has the higher priority, the bridge will generate a new BPDU placing its own bridge identity in the root field. This is then

transmitted onto the network in preference to the received BPDU.

Thus for example, if the bridge 1 received a BPDU from any other bridge, it would determine that the priority of its own bridge identifier B1 was greater than that of the other bridge identifiers B2,B3,B4,B5,B6. Accordingly, any BPDU indicating any other bridge identifier B2,B3,B4,B5,B6 in the root field would be discarded and replaced.

If however the bridge identifier in the root field 21 has a higher priority, then the bridge will update the topology data stored in the memory and generate a new BPDU. The new BPDU will include at least some of the topology details from the received BPDU, along with the bridge's own bridge identifier in the bridge field 21. The newly generated BPDU is then transmitted to all the other bridges accordingly.

In order to determine the designated bridge B1,B2,B3,B4,B5,B6 for a given LAN, the path cost indicated in the BPDU of bridges coupled to the LAN are compared. The bridge having the lowest path cost is then selected.

Thus, in the present example, the bridge 6 will generate a BPDU indicating the path cost of transferring data from the LAN 14 to the root bridge 1. This will be transmitted to the bridge 4 which will compare it to its own path cost and determine its own path cost as lower. Accordingly, the bridge 4 will generate a response BPDU which is returned to the bridge 6. Upon receiving this response BPDU, the bridge 6 will determine that it is not the designated bridge for the LAN 14 and will accordingly block the port 9. Both bridges 4,6 update the topology data accordingly.

This process is repeated throughout the network until all the bridges are configured such that there are no loops within the network.

In addition to this, in order to be able to update the network topology to account for any failures in the network the topology date stored in the bridges must be updated.

In order to do this, the root bridge is configured by the STP to generate a BPDU at regular intervals (such as every two seconds). The other bridges update their topology data in accordance with the information contained in these BPDUs (which often remain the same from one frame to the next). If however the root bridge does not generate a BPDU, or this is at least not received by a bridge, then the affected bridge or bridges wait for a predetermined time-out interval (typically 15 seconds) before generating their own BPDUs thereby allowing an alternative network configuration to be determined.

As with all networks, it is desirable to be able to achieve optimum transfer rates through the network. In the case of networks operating a Spanning Tree Protocol, the networks often consist of a number of LANs interconnected via a number of bridges. Unfortunately, in order to transfer data from one LAN to another, data often has to be transferred via several bridges and several different LANs. The transfer through the local area networks can cause severe delays to the transfer of data.

Thus, for example, in the example of Figure 1, in order to transfer data from the LAN 15 to the LAN 14, the data must be transferred via the bridge 5, the LAN 11, the bridge 1, the LAN 10 and the bridge 4, with the transfer through the bridges 10 and 11 causing the necessary delays.

Furthermore the STP sometimes operates to disable a port of a bridge which may offer a better route through the network. Currently, this can only be overcome by altering the respective priority numbers of the bridges and the ports. This is a complicated task which in practice may not be physically achievable in many larger networks.

In accordance with a first aspect of the present invention, we provide a bridge for use in a group of bridges in a communications network, the communications network having a number of communications devices coupled together via a number of bridges and operating in

accordance with a Spanning Tree Protocol (STP), the bridge comprising:

a number of interconnectable ports;

a group port which couples the grouped bridge to a corresponding group port of at least one other grouped bridge via a group link, the group link being provided to allow ports on different grouped bridges to be interconnected; and,

a processor, the processor being adapted to communicate with other bridges on the network using Bridge Protocol Data Units (BPDUs) to allow an optimum path through the network to be determined, wherein the optimum path is determined in accordance with path cost components which represent the ability of respective ports to transfer data.

Thus the present invention provides a bridge which can be linked to one or more other bridges according to the invention via a dedicated group link. The group link is only used for transferring data between the bridges, thereby removing the need for data to be transferred between bridges across other communication devices such as local area networks, or the like. The bridges according to the invention can be connected to standard network bridges in the normal way.

In accordance with a second aspect of the present invention, we provide a method of implementing a Spanning Tree Protocol (STP) on a communications network including a number of grouped bridges, the communications network having a number of communications devices coupled together via a number of bridges, each grouped bridge having a number of interconnectable ports including a group port which couples the grouped bridge to a corresponding group port of another grouped bridge via a group link, the group link being provided to allow ports on different grouped bridges to be interconnected, wherein the STP causes bridges in the network to communicate with each other using Bridge Protocol Data Units (BPDUs) to determine an optimum

path through the network, the optimum path being determined in accordance with path cost components representative of the ability of respective ports to transfer data, wherein each BPDU includes a bridge identifier representative of the bridge which generated the BPDU, the method comprising:

setting the path cost component of the group port equal to zero;

setting the bridge identifier of each bridge in the group to be equal; and,

each time a bridge in the group receives a BPDU via a port other than the group port, causing the bridge to generate and transmit a new BPDU to the group port, the new BPDU having the bridge identifier and the port identifier of the received BPDU.

Accordingly, we further provide a method of implementing a spanning tree protocol in the communications network which includes a number of grouped bridges. The above described method allows the spanning tree protocol to be implemented such that it does not cause the group link, which links the bridges in the group, to be disabled. This is achieved by effectively treating each bridge in the group as the same bridge so that the Spanning Tree Protocol is not aware that the group link exists, and therefore cannot disable it.

Accordingly, the processor of the bridge is typically adapted to set the path cost components of the group equal to zero. Furthermore, when a BPDU is received via a port other than the group port, the bridge generates a new BPDU based on the received BPDU and having the bridge identifier and the port identifier of the received BPDU, which is then transmitted to the other bridges in the group, via the group port.

Preferably the bridge will include a store which stores the bridge identifier and the path cost component associated with each respective port. However, these may alternatively be stored at other locations on the network.

Typically the bridge includes a transfer store which stores data received at one of the ports before transferring the data to one or more of the other ports. Whilst a system which transfers the data directly from one port to another may be used in some cases, it is preferable to allow the data to be stored temporarily in order to avoid the loss of data due to incorrect transfer.

Typically the STP uses port identifiers and port priority numbers associated with each bridge port. In this case the port identifier and the associated port priority of each port in the bridge are preferably stored in the store.

The bridge identifiers of each bridge in the group of bridges are identical. This allows the STP to treat the bridges as a single bridge for the purposes of determining paths through the network.

In the standard STP operation, the bridge identifier is based on the MAC address of the respective bridge. Typically, each bridge has a respective MAC address, however the bridge identifier of each grouped bridge is typically determined in accordance with the MAC address for one of the bridges in the group. Alternatively, however an entirely separate bridge identifier could be used.

In the present invention, the STP is preferably a modified version of the IEEE 802.1D standard.

It will be realised by a person skilled in the art that the communications devices of the communications network may consist of self-contained networks such as local area networks, or the like or alternatively they may consist of end stations, or a combination of both of the above.

An example of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a schematic representation of a communications network according to the prior art;

Figure 2 is an example of a BPDU used by Spanning Tree Protocols;

Figure 3 is a schematic representation of a communications network including a stack of bridges according to the present invention; and,

Figure 4 is a schematic representation of one of the bridges of the stack of bridges shown in Figure 3.

The network system shown in Figure 3 includes a number of local area networks (LANs) 30,31,32,33,34 which are coupled together via two bridges 35,36 and a group or stack of bridges 40. The stack of bridges is a group of four bridges 41A,41B,41C,41D having a number of respective ports 42(A-D), 44(A-D), 45(A-D), 46(A-D). The bridges 41A,41B,41C,41D are coupled to a dedicated stack link 43 via the respective ports 42A,42B,42C,42D. The LANs 30,31,32,33,34 are coupled to the bridges 35,36,41A,41B,41C,41D via the ports 37,38,39,44,45,46 as shown.

An example of a bridge 41, which may be used as one of the bridges 41A,41B,41C,41D, of the stack of bridges 40, is shown in more detail in Figure 4. As shown, each of the ports 42,44,45,46 of the bridge 41 are coupled together via a bus 50.

Also coupled to the bus 50 is a First In First Out (FIFO) buffer memory 47, which is used to temporarily store data which is being transferred between the ports 42,44,45,46. There is also provided a processor 48 which controls the operation of the bridge 41 as well as implementing the STP. The processor is coupled to a memory 49 which stores details of the network topology in the form of topology data as required by the BPDU.

Operation of the network to implement a Spanning Tree Protocol is substantially as described with respect to Figures 1 and 2 for the standard Spanning Tree Protocol. Accordingly, the processors 48 of the bridges 41, and respective processors (not shown) of the bridges 35,36 communicate with each other, using BPDUs to determine the

current network topology. This information is stored in the memory 49 of each bridge 41, and in the equivalent memory of the bridges 35,36, and is used to maintain a single path through the network.

For the purposes of the present example, the root bridge is assumed to be the bridge 35.

As will be realised, the stack link 43 is provided solely for the purpose of transferring data between the bridges 41A,41B,41C,41D and it is therefore preferable to transfer data via the stack link, as opposed to via any other route. In order to achieve this, the STP is implemented so as to disable any alternative paths connecting the bridges 41A,41B,41C,41D in the stack 40.

Thus, in the present example, the STP will cause the network to disable the path via the LANs 32,34 and the bridge 36 which links the bridges 41A,41C. This ensures that all data is transferred between the bridges 41A,41C via the stack link.

In order to achieve this, the network must determine that the lowest cost path from the LAN 34 to the root bridge 35 is via the bridge 41C and the stack link 43, as opposed to via the bridge 36 and the LAN 32.

Accordingly, the stack ports 42A,42B,42C,42D are assigned a path cost component of zero such that there is no path cost for transferring data between the bridges 41A,41B,41C,41D via the stack link 43. As a result, the transfer of data via the stack link does not add to the overall cost of paths back to the root bridge 35.

However in normal STP, a zero path cost cannot occur as the transfer of data via any port will add a path cost component to the overall path cost. Accordingly, if a zero path cost is indicated, the STP interprets this as if a bridge is transferring data to itself.

Accordingly, with a zero path cost defined for the transfer of data via the stack link, the STP interprets the transfer of data between bridges 41A,41B,41C,41D as the transfer of data from a bridge to itself.

In order for the STP to operate, each of the bridges 41A,41B,41C,41D therefore has to be assigned the same bridge identifier, such that the STP interprets the stack 40 to be a single bridge.

In normal STP, the bridge identifiers are based on a modified version of the MAC address of each respective bridge. Accordingly, in the present invention, the bridge identifier of each of the bridges 41A,41B,41C,41D is based on the MAC address of one of the bridges 41A,41B,41C,41D. Thus for example, each bridge would be assigned the identifier B41A based on the MAC address 41A of bridge 41A.

As will be appreciated, this is either achieved automatically by the processors 48 of the bridges 41, or the identifiers are pre-programmed into the memory 49 of the bridges 41.

A further complication however is that normal STP does not allow for a bridge to receive a BPDU from itself. Under normal STP operation, when a bridge generates a BPDU, it will include its own bridge identifier in the bridge field 20. To overcome this, the bridges 41A,41B,41C,41D are designed to respond to any BPDU received at one of the ports 44,45,46 by generating a new BPDU which includes the bridge identifier from the bridge field 20 of the received BPDU. This new BPDU is then transmitted via the stack link 43 to the other bridges 41A,41B,41C,41D in the stack.

Thus, in the present example, if the bridge 35 generates a BPDU, this indicates its own bridge identifier B35 in both the bridge field 20 and the root field 21. The BPDU is then transmitted to the stack of bridges 40. Assuming the network is still in the process of determining the desired network topology, then the BPDU will be received by bridges 41A,41B on the respective ports 44,46.

Once the bridges 41A,41B have made appropriate amendments to the topology data stored in the respective memories 49, each bridge generates a new BPDU which includes the bridge identifier B35 in the bridge and root fields 20,21. In this case, because no modification of the

data has occurred, the entire contents of the new BPDU is identical to that of the received BPDU. The BPDU is transferred via the stack link 43 to each of the other bridges in the stack 40. In this case, the bridges 41A,41B will receive a second copy of the BPDU which will be ignored as the data in the BPDU is identical to the topology data already stored in the memory 49. The bridges 41C,41D however will receive the unmodified BPDU and act as though it were received directly from the bridge 35.

This ensures that each bridge 41A,41B,41C,41D stores the same topology data and therefore effectively acts as part of a single bridge.

In order to be able to transfer data successfully around the network, this means that each port 44,45,46 of each bridge 41A,41B,41C,41D must have a respective unique port identifier. As a result of this, the stack of bridges 40 appears to the remainder of the network as though it is a single bridge with a large number of ports. This therefore prevents the stack link 43 from being disabled due to the STP.

In the case in which the stack of bridges 40 becomes designated as the root bridge, the only modification to the STP is that any Topology Change Notification BPDUs (TCN) (a type of BPDU known in the art) must propagate to each bridge 41A,41B,41C,41D in the stack of bridges 40. Each bridge will then generate its own respective BPDUs which are output via the ports 44,45,46 onto the remainder of the network, and which now include a flag indicating a topology change has occurred.

An example of the implementation of the modified STP to determine a network configuration will now be described.

Firstly, as mentioned above, the bridge 35 has the highest priority and this is therefore determined to be the root bridge 35. As a result the ports 39 of the bridge 35 become the designated ports for the respective LANs 30,31.

Next the STP operates to determine the root ports of the bridges 36,41A,41B,41C,41D. Assuming that the path

cost component of the port 44A is higher than that of the port 46B, then as the ports 42A,42B do not add to the path cost component, then the port 42A becomes the root port for the bridge 41A. Similarly, the ports 46B,42C,42D are the root ports of the bridges 41B,41C,41D respectively.

As the port 44A is neither a designated nor a root port, it is placed in a blocking state, therefore removing the loop defined by the bridges 41A,41B,35, the LANs 30,31 and the stack link 43.

As can be seen, in this case, the stack of bridges 40 is effectively one overall bridge with a single root port which is the root port 46B.

Similarly, the network determines the designated bridges for the LANs 32,33,34 to be the bridges 41A,41D,41C with these bridges having respective designated ports 45, as shown.

Finally, the bridge 36 includes a root port 38 and a port 37 which is neither a root port nor a designated port. Accordingly, the bridge 36 operates to block the port 37 thereby disabling the link to the LAN 34.

It will be appreciated, that in addition to the bridges 41 described above, the present invention must utilise an appropriately modified version of the IEEE 802.1D Spanning Tree Protocol standard.

CLAIMS

1. A bridge for use in a group of bridges in a communications network, the communications network having a number of communications devices coupled together via a number of bridges and operating in accordance with a Spanning Tree Protocol (STP), the bridge comprising:

a number of interconnectable ports;

a group port which couples the grouped bridge to a corresponding group port of at least one other grouped bridge via a group link, the group link being provided to allow ports on different grouped bridges to be interconnected; and,

a processor, the processor being adapted to communicate with other bridges on the network using Bridge Protocol Data Units (BPDUs) to allow an optimum path through the network to be determined, wherein the optimum path is determined in accordance with path cost components which represent the ability of respective ports to transfer data.

2. A bridge according to claim 1, wherein each BPDU includes a bridge identifier representative of the bridge which generated the BPDU wherein the processor is adapted to set the path cost component of the group port equal to zero and each time a bridge in the group receives a BPDU via a port other than the group port, to cause the bridge to generate and transmit a new BPDU to the group port, the new BPDU having the bridge identifier and the port identifier of the received BPDU.

3. A bridge according to claim 2, the bridge including a store which stores the bridge identifier and the path cost component associated with each respective port.

4. A bridge according to claim 3, wherein the STP uses port identifiers and port priority numbers associated with each bridge port, wherein the port identifier and associated port priority of each port in the bridge are stored in the store.

5. A bridge according to any of the preceding claims, wherein the bridge includes a transfer store which stores data received at one of the ports before transferring the data to one or more of the other ports.

6. A bridge for use in a group of bridges in a communications network, the communications network having a number of communications devices coupled together via a number of bridges and operating in accordance with a Spanning Tree Protocol (STP), substantially as hereinbefore described with reference to Figures 3 and 4.

7. A group of bridges comprising a number of bridges according to any of claims 1 to 6, the bridges being coupled via a group link which interconnects the group ports on different bridges in the group.

8. A group of bridges according to claim 7 wherein the bridge identifier of each bridge in the group of bridges is identical.

9. A group of bridges according to claim 8, wherein each bridge has a respective MAC address, the bridge identifier of each grouped bridge being determined in accordance with the MAC address of one of the bridges in the group.

10. A group of bridges according to any of claims 7 to 9, when dependent on claim 5, wherein the port identifiers and the associated port priority numbers are different for each bridge port of each grouped bridge.

11. A group of bridges substantially as hereinbefore described with reference to Figures 3 and 4.

12. A method of implementing a Spanning Tree Protocol (STP) on a communications network including a number of grouped bridges, the communications network having a number of communications devices coupled together via a number of bridges, each grouped bridge having a number of interconnectable ports including a group port which couples the grouped bridge to a corresponding group port of another grouped bridge via a group link, the group link being provided to allow ports on different grouped bridges to be interconnected, wherein the STP causes bridges in the

network communicate with each other using Bridge Protocol Data Units (BPDUs) to determine an optimum path through the network, the optimum path being determined in accordance with path cost components representative of the ability of respective ports to transfer data, wherein each BPDU includes a bridge identifier representative of the bridge from which the BPDU was received, the method comprising:

setting the path cost component of the group port equal to zero;

setting the bridge identifier of each bridge in the group to be equal; and,

each time a bridge in the group receives a BPDU via a port other than the group port, causing the bridge to generate and transmit a new BPDU to the group port, the new BPDU having the bridge identifier and the port identifier of the received BPDU.

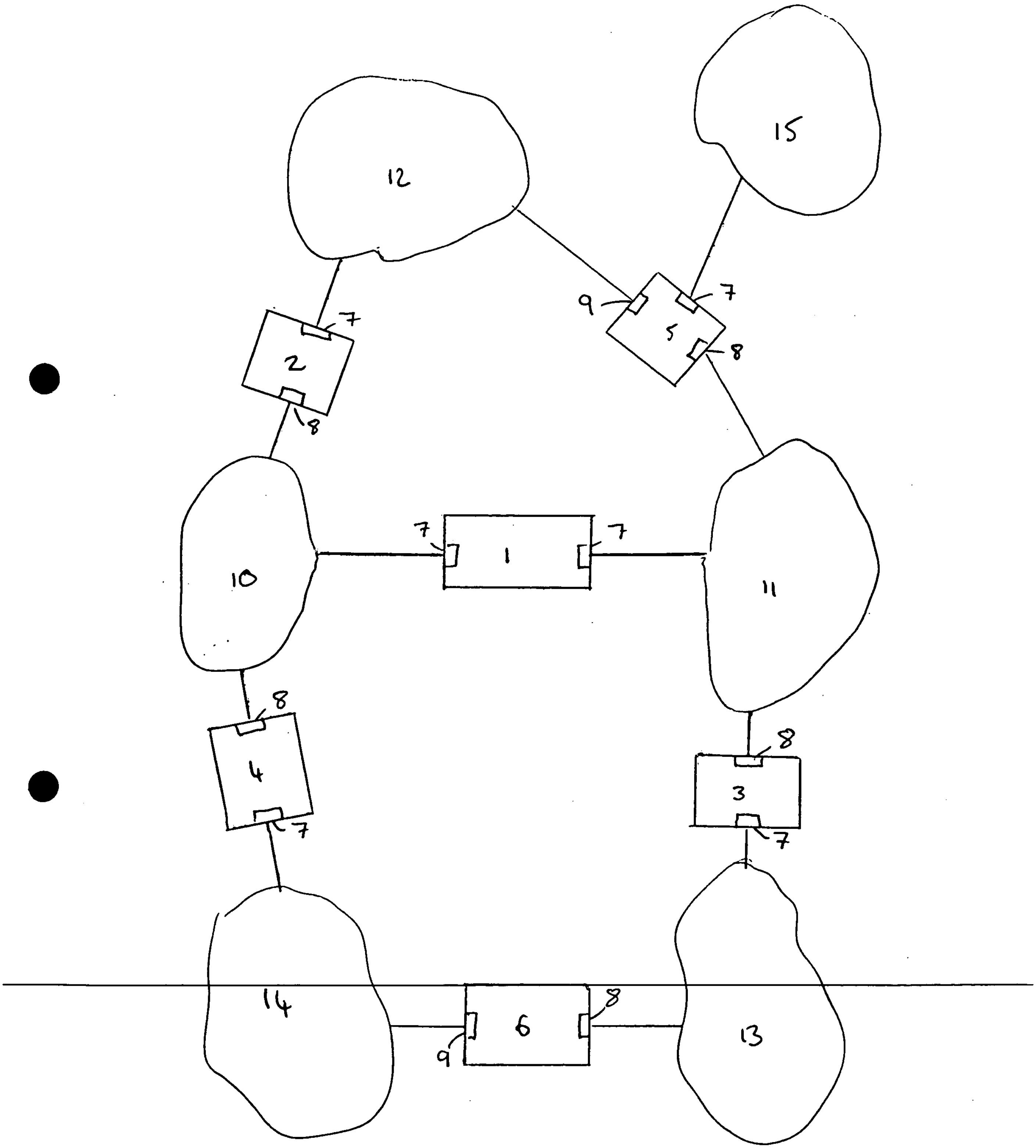
13. A method according to claim 12, each grouped bridge having a respective MAC address, the bridge identifier of each bridge in the group being determined in accordance with the MAC address of one of the bridges in the group.

14. A method according to claim 12 or claim 13, wherein the STP uses port identifiers and port priority numbers associated with each bridge port, the method further comprising assigning a unique port identifier and associated port priority number to each port in the group of bridges.

15. A method according to any of claims 12 to 14, wherein the STP is a modified version of that defined by the IEEE 802.1D standard.

16. A method of implementing a Spanning Tree Protocol (STP) on a communications network including a number of grouped bridges, substantially as hereinbefore described with reference to Figures 3 and 4.

Figure 1.



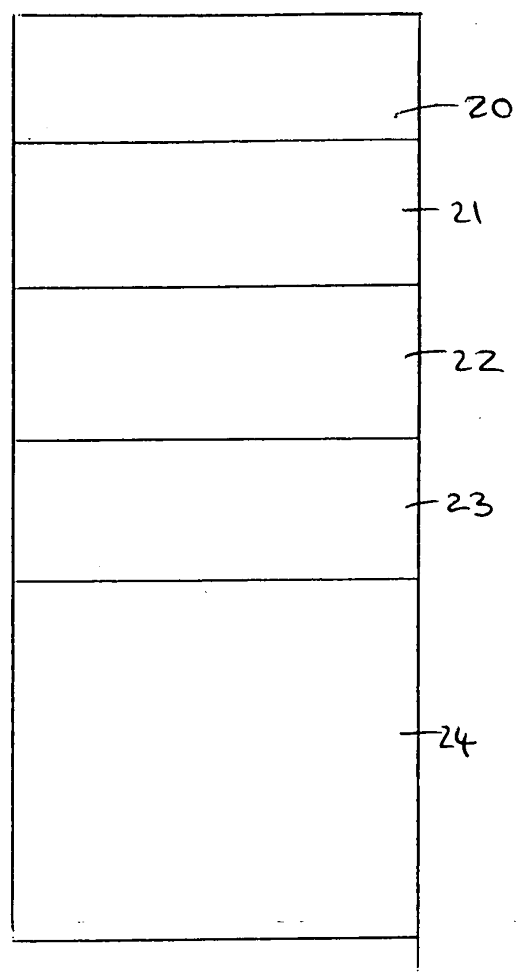


Fig.2

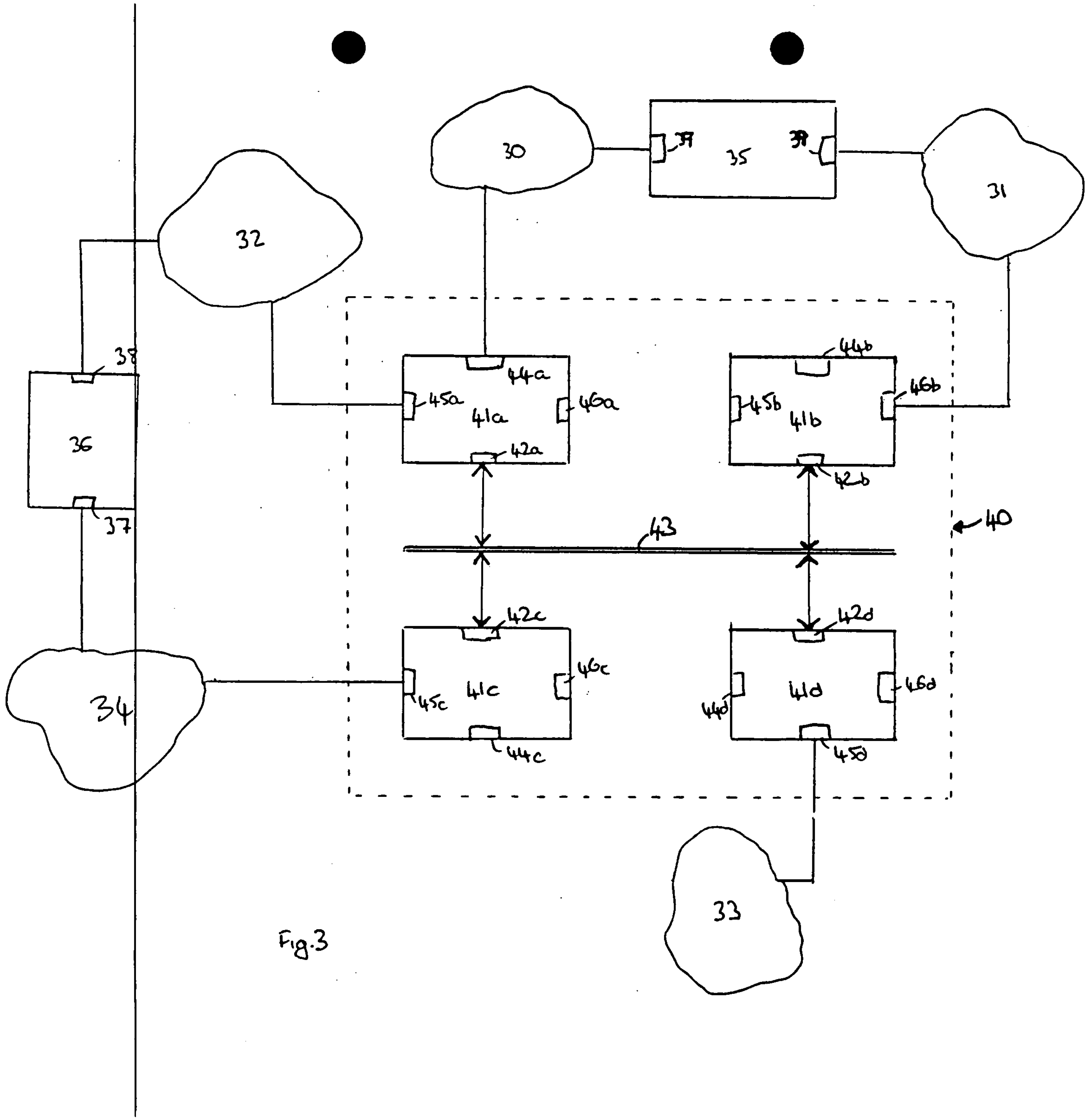

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Fig.3

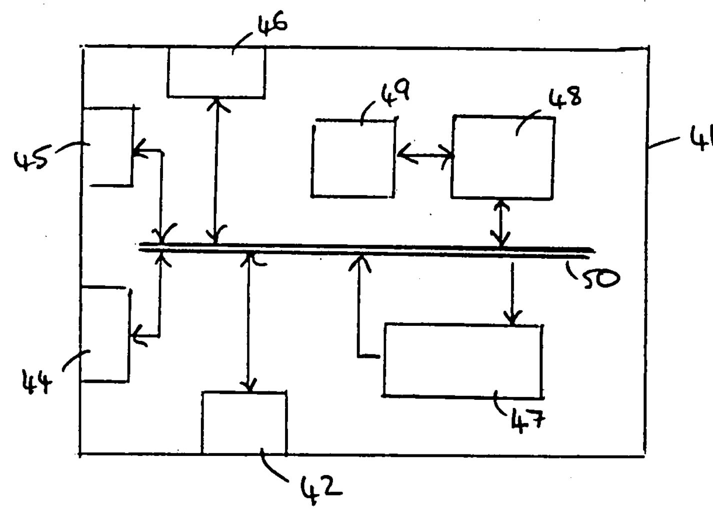

Figure 4.

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